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(54) PUSH BUTTON SWITCH

(71) We, MATSUSHITA ELECTRIC INDUSTRIAL COMPANY LIMITED, a corporation organised under the laws of Japan of 1006 Oaza Kadoma, Kadoma-shi, Osaka, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to electrical push button switches comprises an elastic conductive sheet with a dimple for providing a double snap-action. Such switches are particularly suitable for keyboards on desktop electronic calculators or push-button telephone sets.

According to the present invention, an electrical push button switch comprises an elastic conductive sheet having a part-spherical dimple with an annular shoulder, said dimple being deformable with a double snap-action upon depression thereof, the switch including a fixed contact or contacts having portions extending adjacent respective portions of the annular shoulder and spaced therefrom whereby, the first snap-action of the dimple, upon depression thereof, causes said annular shoulder portions to make contact with said portions.

The annular shoulder in the dimple in the above switch provides a double snap-action which has the advantages of maintaining reliable electrical contact between the dimple and the contact portions which are spaced therefrom. Contact chatter is thereby avoided. Moreover, the second snap-action, wherein the dome of the dimple is depressed to the level of the contacts, provides additional lost motion which improves the feel of the switch.

Prior art switches and embodiments of the invention will now be described with reference to the accompanying drawings, in which:

Figs. 1 and 2 are sectional views showing

prior art push button switches using a conductive elastic sheet;

Fig. 3 is an exploded perspective view of a keyboard switch assembly for an electronic calculator using push button switches according to the invention;

Figs. 4a to 4d illustrate different stages in the deformation of a part-spherical protuberance of a push button switch according to the invention;

Fig. 5 is a sectional view showing part of a push button switch, according to the invention, with a different contact arrangement;

Figs. 6 and 7 are sectional views showing other push button switches according to the invention;

Figs. 8a to 8c show examples of part-spherical protuberances having nodal characteristics;

Figs. 9 and 10 are sectional views showing further push button switches according to the invention;

Fig. 11 is a view showing a conductor pattern on the printed circuit board of a prior art push button switch; and

Figs. 12 to 14 are views showing conductor patterns on a printed circuit board which can be employed with a push button switch according to the invention.

Prior art switches having metal make and break contacts are prone to contact chatter. Moreover, if excessive contact pressure is repeatedly used, the contacts wear quickly resulting in contact instability. These factors are undesirable with regard to the reliability, durability and safety of the switch.

Various types of switches have been proposed for overcoming the above drawbacks. For example, push button switches in which a conductive elastic sheet is brought into contact with conductors printed on a printed circuit board, normally held underneath the conductive elastic sheet at a predetermined distance therefrom, can be classed into two types as exemplified by Figs. 1 and 2.

The switch of the type shown in Fig. 1 comprises a printed circuit board 1 having two contacts 2 and 2' printed thereon, a return spring member such as a coil spring 3, a push-button 5 held in a frame 4 and having a downward integral extension 6, and a conductive elastic sheet piece 7 provided at the lower end of the extension 6 and having an area capable of covering both the contacts 2 and 2'. The other type of switch shown in Fig. 2 has a construction consisting of a printed circuit board 1 having two contacts 2 and 2' printed thereon, a return spring member such as a coil spring 3, a push-button 5 held in a frame 4 and having a downward integral extension 6 and a conductive elastic sheet 7' supported on a spacer intervening between printed circuit board 1 and elastic sheet 7' to hold the elastic sheet above and at a slight distance from the contacts 2 and 2'.

The switches of both these types are actuated or closed when the contacts 2 and 2' are contacted by the conductive elastic sheet piece 7 or elastic sheet 7' due to vertical displacement of the elastic sheet towards the contacts 2 and 2' on the printed circuit board 1 caused by depressing the button 5.

In the switches of the above constructions, however, the elasticity of the conductive elastic sheet piece 7 or elastic sheet 7' constituting an element of the switch is not fully utilized. Also, since the elastic sheet piece is displaced in the vertical direction with respect to the contacts, the closing of the switch is achieved only at the end of the downward stroke of the button 5. In other words, no play is provided for any extra movement of the button after the switch is actuated, and the switch will not be actuated until the button is depressed through its full stroke. Therefore, the button 5 is subject to excessive pressure leading to wear of the contact area. Further, since a button return spring 3 is used, the spring and the conductive elastic sheet are likely to resonate due to the elasticity of the spring and the complex elasticity of the conductive elastic sheet. This increases the possibility of contact chatter, which is itself a deterrent to the use of such switches, and it also adversely affects the user's power or skill to operate the button, which leads to switch malfunctions.

A push button switch according to the invention will now be described in connection with Figs. 3—10 and 12—14 of the drawings.

Fig. 3 shows a keyboard switch assembly for a desk-top electronic calculator which employs push button switches according to the invention. A plurality of push buttons such as 30 are supported in a frame 31 such that each can be moved vertically. An

elastic conductive sheet formed with a plurality of part-spherical protuberances 33 each formed at a position corresponding to the associated button 30. An insulating sheet 34 is formed with holes 35 each corresponding in position to the associated part-spherical protuberance 33. A printed circuit board 36 having conductor patterns 37 printed thereon is formed with small holes 38 each for each switch. Numeral 39 designates a dust filter.

Figs. 4a to 4d show different stages in the deformation of the main operative part of a switch according to the invention, which part comprises a printed circuit board 9 having contacts 10 and 10' formed thereon by means of printed circuit technique, a conductive elastic sheet 11 having a part-spherical protuberance 20 with a flexural node for two-step deformation and with a spacer 12 for insulating the sheet 11 from the printed circuit on the printed circuit board. In this embodiment, the protuberance 20 is brought into contact with the contacts 10 and 10' when it is depressed by a button (not shown) to close an associated electric circuit.

Fig. 4a shows the "off" state without any pressure exerted on protuberance 20. When pressure is exerted on the protuberance 20 for actuating the switch, the conductive elastic sheet 11 deforms about the flexural node of the protuberance 20 as shown in Fig. 4b. Then, as the first step, the flexural node or annular shoulder part of the protuberance 20 is brought into contact with the contacts 10 and 10' on the board 9 as shown in Fig. 4c. Subsequently, the conductive elastic sheet 11 undergoes a second deformation as shown in Fig. 4d. This second deformation provides play or lost motion which improves the 'feel' of the switch (through the operating button, not shown) and its reliability of operation. The protuberance 20 has a double snap-action due to its elasticity and the provision of an annular shoulder portion. No flexure takes place, however, until a certain predetermined pressure is exceeded whereupon the protuberance undergoes a sudden flexural deformation.

When the pressure is removed, the protuberance 20 is quickly restored to its initial state whereby it is separated from the contacts 10 and 10', thus opening the associated electric circuit. This also ensures reliable operation. It is possible to preset the point at which the first snap-action takes place (Fig. 4c) with respect to the total displacement from the state shown in Fig. 4a to the state shown in Fig. 4d so as to provide for the play or lost motion from the state shown in Fig. 4c to the state shown in Fig. 4d.

As the protuberance 20 provides a large

restoring force, a coil spring for returning the push button, as used in the prior art, can be omitted, thereby saving expense.

Fig. 5 shows a modification wherein contact 10 and conductive elastic sheet 11 are always in contact with each other, and the flexural node or annular shoulder portion of the part-spherical protuberance 20 is brought into contact with the other contact 10¹ which extends beneath the annular shoulder portion.

Figs. 6 and 7 show push button switches according to the invention. In these switches, the push button 44 is made of an insulating material and is mounted in a hole formed in the upper wall of a frame 13 such that it can be moved vertically. The main operative part of each switch, corresponding respectively with the parts shown in Figs. 4a-4d and Fig. 5, is positioned below the button 44. The operation of the switches in Figs. 6 and 7 will be understood from the foregoing description of Figs. 4a-4d and Fig. 5.

The snap-action and the return characteristics may be preset by selecting the hardness and thickness of the conductive elastic sheet and the shape and dimensions of the flexural node of the part-spherical protuberance.

Figs. 8a to 8c show alternative shapes of part-spherical protuberances each having a flexural node for two-step deformation. These and other shapes may be appropriately selected to match the design values of the push button switch depressing pressure, stroke and so forth. Also, where a plurality of push button switches are assembled on a keyboard for a desk-top electronic calculator or push button telephone sets, savings in manufacture can be made by using a single sheet formed with a plurality of part-spherical protuberances suitably spaced, one from another on the conductive elastic sheet 11.

Fig. 9 shows a further embodiment of the invention, comprising a frame 51, a push-button 52 of an insulating material mounted for vertical movement in a hole formed in the top wall of the frame 51, a conductive elastic sheet 53 disposed below the button 52 and having a part-spherical protuberance, contacts 54 and 54¹ facing the protuberance and formed on a board 56 (the board 56 having a small vent 55), and a spacer 57.

In operation, when the button 52 is downwardly depressed, the protuberance of the sheet 53 undergoes flexural deformation and is brought into contact with the contacts 54 and 54¹ to close the associated electric circuit. When the applied pressure is removed, the electric circuit is opened due to the flexural restoring characteristics of the protuberance in sheet 53. The vent

55 enables air to escape from, or enter the cavity beneath the protuberance in the sheet 53.

Fig. 10 shows a further embodiment of the invention comprising a switch frame 51, a push-button 52 made of an insulating material and mounted for vertical movement in a hole formed in the top wall of frame 51, a conductive elastic sheet 53 disposed below the button 52 and having a part-spherical protuberance, contacts 54 and 54¹ facing the protuberance and formed on a board 56 formed with a small hole 55, an insulating spacer 57 and a cloth-like insulator 58 which serves as an air filter.

When button 52 is depressed, the part-spherical protuberance of sheet 53 undergoes flexural deformation and is brought into contact with contacts 54 and 54¹ to close an associated electric circuit. When the applied pressure is removed, the electric circuit is opened due to the restoring force of the elastic sheet 53. Air is allowed to enter and leave the cavity beneath the part-spherical protuberance via vent 55.

The insulating filter 58 is made of porous or net-like material to permit air but not dust to pass through it. Whilst felt is the best material, plastics such as urethane foam having thin continuous pores may also be used. The filter may extend over the entire back area of the board 56 or over a vent 55. As the size of the vent 55 controls the flow of air into the cavity beneath the part-spherical protuberance, the size of the vent can be selected further to ensure against resonance and bounce phenomena, as well as contact chatter, where such further precautions are necessary. The switching contacts can be kept dust-free, by use of a suitable filter.

Figs. 11 to 14 show conductor patterns for a printed circuit board. Fig. 11 shows a prior art pattern. With such a simple pattern, consisting of two separate rectangles, a steady and stable contact state is not likely to be obtained (depending upon the shape and structure of the conductive material brought into contact with the contacts), giving rise to contact chatter.

Figs. 12 to 14 show conductor patterns which can assist further to prevent contact chatter. Combination of comb-like contact patterns assist in providing stable contact with the conductive elastic material again improving the reliability of the switch.

WHAT WE CLAIM IS:—

1. An electrical push-button switch comprising an elastic conductive sheet having a part-spherical dimple with an annular shoulder, said dimple being deformable with a double snap-action upon depression thereof, the switch including a fixed contact or contacts having portions extending adja-

- cent respective portions of the annular shoulder and spaced therefrom whereby, the first snap-action of the dimple, upon depression thereof, causes said annular shoulder portions to make contact with said portions.
- 5 2. A switch according to claim 1 including a push-button slidably supported above said dimple for depression thereof, said contact or contacts being provided on
- 10 a printed circuit board spaced from said dimple.
3. A switch according to claim 1 or 2 in which said contacts comprise a pair of conductive regions on a printed circuit
- 15 board.
4. A switch according to claim 3 wherein said conductive regions each have comb-shaped patterns.
5. A switch according to any one of the
- 20 preceding claims wherein said dimple is part of an elastic sheet, and wherein the contacts are provided on a support having a vent communicating with a cavity defined by the dimple whereby air can enter or
- 25 leave said cavity.
6. A switch according to claim 5 including a dust filter adjacent said vent.
7. A switch according to any one of the preceding claims wherein the dimple,
- 30 forming part of an elastic sheet, is secured with an insulating spacer and a printed circuit board supporting said contact or contacts in a frame, which frame slidably supports the push button.
- 35 8. A switch substantially as herein described with reference to Figs. 4a-4d and 6 of the accompanying drawings.
9. A switch substantially as herein described with reference to Figs. 5 and 7 of the accompanying drawings.
- 40 10. A switch substantially as herein described with reference to Fig. 9 of the accompanying drawings.
11. A switch substantially as herein described with reference to Fig. 10 of the accompanying drawings.
- 45 12. A switch according to claim 1 with a dimple substantially as herein described with reference to Fig. 8a of the accompanying drawings.
- 50 13. A switch according to claim 1 with a dimple substantially as herein described with reference to Fig. 8b of the accompanying drawings.
14. A switch according to claim 1 with a dimple substantially as herein described with reference to Fig. 8c of the accompanying drawings.
- 55 15. A switch according to claim 1 in which said contacts are substantially as herein described with reference to Fig. 13 of the accompanying drawings.
- 60 16. A switch according to claim 1 in which said contacts are substantially as herein described with reference to Fig. 14 of the accompanying drawings.
- 70 17. A keyboard having a plurality of push button switches according to claim 1 and substantially as herein described with reference to Fig. 3 of the accompanying drawings.
- 75

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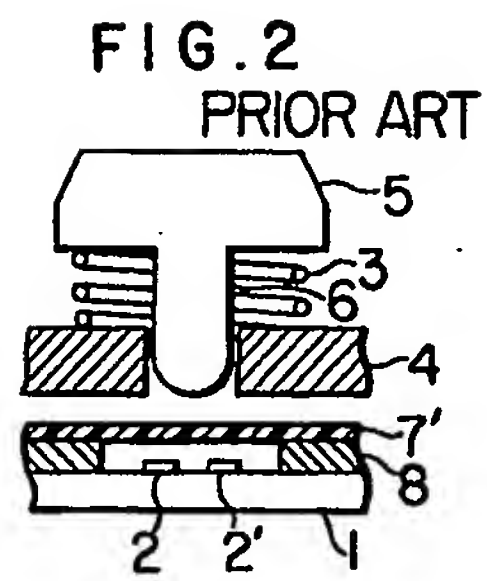
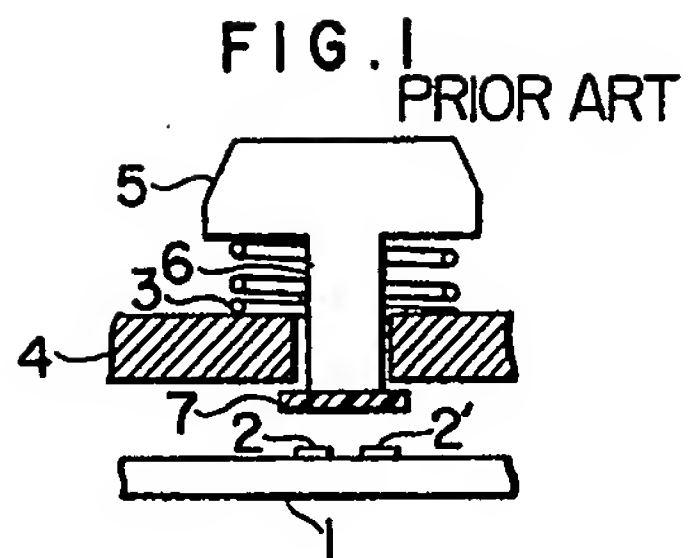


FIG. 3

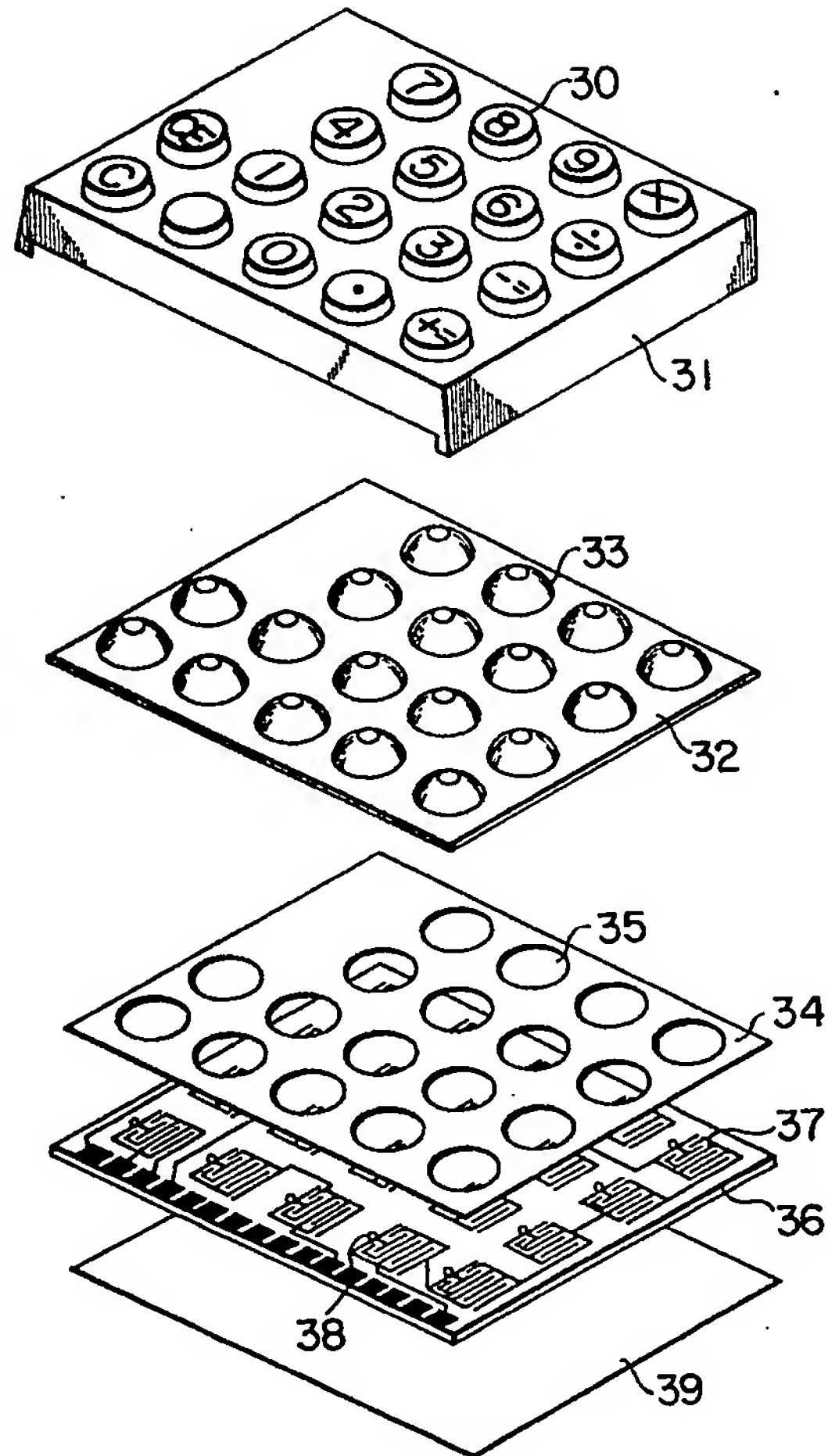


FIG. 4a

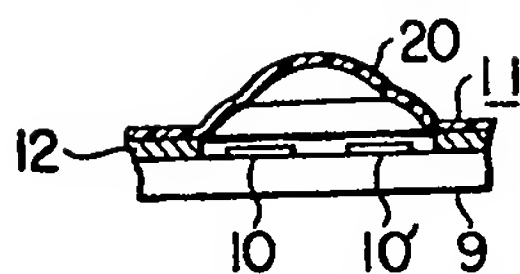


FIG. 4b

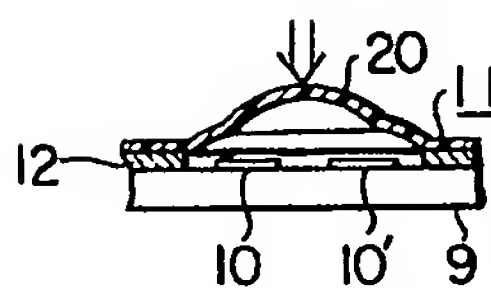


FIG. 4c

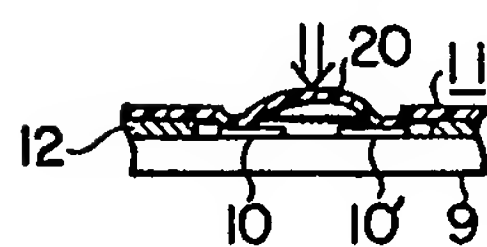


FIG. 4d

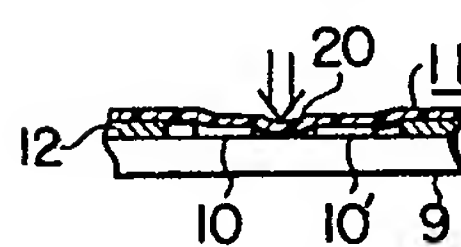


FIG. 5

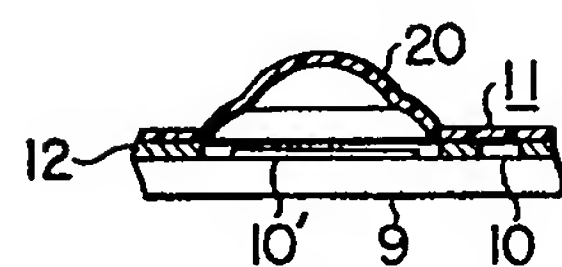


FIG. 6

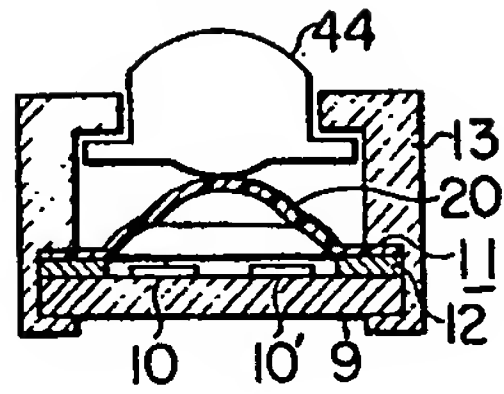


FIG. 7

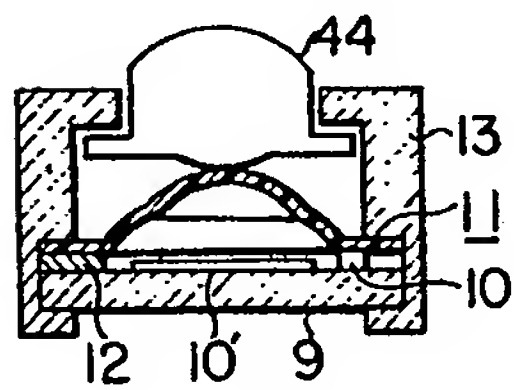


FIG. 8a



FIG. 8b



FIG. 8c



FIG. 9

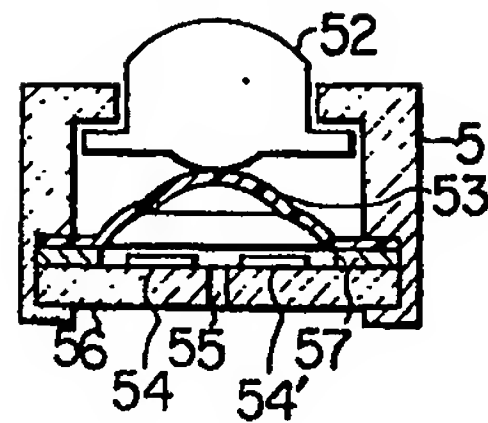


FIG. 10

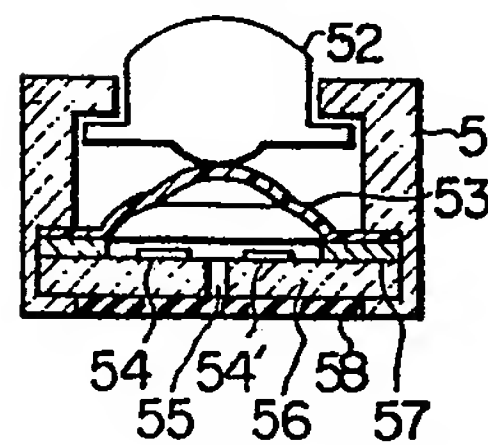


FIG. 11



FIG. 12

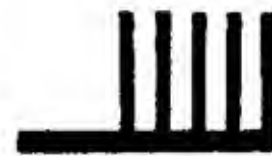


FIG. 13



FIG. 14

